TECHNICAL REPORT NAVTRAEQUIPC[redacted] IH-304

INSTRUCTIONAL SYSTEMS DESIGN: THE NAVAIR/NAVTRAEQUIPCEN MODEL

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44 p.

Jul[redacted]78

Final Report, [redacted] Jan[redacted]976 — Jul[redacted]78

DoD Distribution Statement

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NAVTRAEQUIPCEN IH-304	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Instructional Systems Design: The NAVAIR/NAVTRAEQUIPCEN Model		5. TYPE OF REPORT & PERIOD COVERED Final Report for Period January 1976 - July 1978
		6. PERFORMING ORG. REPORT NUMBER NAVTRAEQUIPCEN IH-304
7. AUTHOR(s) CDR Joseph F. Funaro and B. E. Mulligan, Ph.D.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Training Equipment Center Orlando, FL 32813		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NAVTRAEQUIPCEN Task No. 6754-01P1
11. CONTROLLING OFFICE NAME AND ADDRESS Commanding Officer Naval Training Equipment Center Orlando, FL 32813		12. REPORT DATE July 1978
		13. NUMBER OF PAGES 38
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Instructional Systems Development (ISD), Systems Approach to Training (SAT), Instructional Models, NAVAIR/NAVTRAEQUIPCEN Model, Management Systems, Training, Training Management Systems, Training System Development

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents a nontechnical description of the Instructional Systems Development (ISD) model currently in use throughout Naval aviation. A brief review is also given of the historical antecedents and evolutionary development of the NAVAIR/NAVTRAEQUIPCEN model by the ISD group at the Naval Training Equipment Center, Orlando, FL. The model provides standardized procedures and decision strategies for carrying out the analysis, design, development, implementation, and quality control of large-scale training programs for

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S/N 0102-014-6601

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(CONTD from block 20)

NAVTRAEQUIPCEN model may be applied in the development of training programs for either existing weapons systems or newly emerging weapons systems.

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INTRODUCTION

HISTORICAL ANTECEDENCE

The unprecedented development of increasingly complex weapon systems during World War II was accompanied by a corresponding need for training programs that could effectively prepare sufficient numbers of military personnel to operate and maintain these systems. At that time, however, neither the psychology of learning and performance, nor educational methodology, were sufficiently advanced to offer any fundamentally new approach to the problem of large-scale training and little appears to have been accomplished during this period other than the emergence of the problem itself.

At the same time an even more basic problem arose in response to the growing complexity of weapons systems, viz., the problem of understanding the integrated functions of conceptually difficult systems. An approach to this problem that proved successful was introduced in the early 1950s and came to be called "systems analysis." Because this methodology offered a means by which the functional relationships among component processes of complex systems could be established, it also provided an approach for evaluating the training requirements inherent to these systems. This new methodology continued to be developed throughout the decade of the 1950s, although the application of systems analysis to instructional design of training programs was largely regarded as a job for the instructional specialist. Consequently, little progress was made toward the development of a proceduralized methodology which could be applied by military personnel. By the end of the decade, however, this situation had begun to change.

Total reliance on instructional specialists for training problem analysis and program development was found to be undesirable. The cost of specialist services was more expensive than that of military personnel, and specialist-developed programs often lacked sufficient inputs from military subject matter experts for the programs to be realistically valid. Even more serious concerns with the nonproceduralized specialist approach stemmed from inadequate development of management and quality control processes to assure uniformity and continuity throughout the life cycle of training programs. While these problems indicated the need for a new methodology, the factors that had provided the basic impetus for the original methodology (weapons systems complexity, training time-cost constraints, trained personnel throughput demands, and limited availability of applicable innovations in instructional technology) were now of even larger magnitude and they virtually required a new, more standardized methodology.

The decade of the 1960s brought a flourish of methodological activity in all of the armed services, especially in those areas where weapon system operation and maintenance had reached a level of complexity that required special training. More than 100 technical manuals were generated during this period, each prescribing a highly proceduralized method of analyzing training problems and developing training programs. A comprehensive bibliography of the literature was compiled by Montemerlo and Tennyson (1976)[1].

While the various methods, for example, Systems Engineering of Training, Training Situation Analysis, Developmental Approach to Training, Design of Instructional Systems, Systems Approach to Training, etc. differed in detail, they all attempted to incorporate the systems analysis approach into the framework of a standardized set of procedures which could be, at least partially, applied by a nonspecialist personnel. Although this effort to achieve some standardization in the instructional design process resulted in procedures that were often so narrow in scope that general applicability was sacrificed, the overall process involved in this effort may be viewed as a kind of evolutionary development where success is measured in terms of the survival of the approach rather than in terms of a specific outcome from any particular application of it. That the approach has been successful in this sense, if in no other, is substantiated by the fact that it has persisted into the latter part of the present decade, and it is continuing to evolve both in scope and applicability.

An advanced form of the systems approach to training has been developed under the auspices of the Naval Air Systems Command by the Naval Training Equipment Center (NAVTRAEQUIPCEN). This comprehensive extension of ISD has come to be known as the NAVAIR/NAVTRAEQUIPCEN model. The model is presented in detail in a document entitled "Training Requirements for Aviation Weapon Systems" (Specification MIL-T-29053 draft, October 1977). An expanded treatment of the model was prepared by Courseware, Inc.[2] A nontechnical description of the major points of the NAVAIR/NAVTRAEQUIPCEN model is given in this report.

EVOLUTION OF THE NAVAIR/NAVTRAEQUIPCEN MODEL

Various applications of the Systems Approach to Training (SAT) were attempted by the Navy during the 1969s and early 1970s, with varying degrees of success. Although the basic concept appears to have been sound, applications of SAT were largely isolated responses to specific training needs with little uniformity from one application to another. Thus, there was no general mechanism for applying SAT in different training situations, nor did there exist any means for evaluating SAT as a whole by examining specific applications of it. Given this state of affairs, further growth in either the concept of SAT. or its applicability, was practically precluded.

The Navy needed a system for developing and managing its training programs which would be sufficiently general to assure a wide range of application without sacrificing the degree of specificality required for quality control and revision. The needed system would have to provide mechanisms for integrating

1. Montemerlo, M. D. and Tennyson, M. E. (February, 1976) "Instructional Systems Development: Conceptual Analysis and Comprehensive Bibliography," NAVTRAEQUIPCEN Report No. IH-257.
2. Courseware, Inc. (June, 1977) "Fleet Aviation Instructional Systems Development Model," Courseware Technical Report, Vols. I-VII.

the activities of the various Naval organizations and independent contractors who contribute resources and services essential to training program development and implementation. Also, the system would have to specify procedures for accomplishing each individual phase of training program development from initial problem identification and analysis on through to final implementation of the completed training program. These procedures would need to be detailed enough, (a) to permit valid projections of time, personnel, resources, and cost requirements for each phase in the development of the new program, (b) to enable effective management control of the time-rate of development and quality of output from developers, (c) to ensure adequate delineation of the roles, responsibilities, and training required of all personnel participating in the project both before and after program implementation, and (d) to assure the availability of resources and trained personnel necessary for a smooth and effective transition from the developmental process to the actual process of managing an ongoing training program.

In addition, the new system should incorporate those essential aspects of the SAT concept that had proved to be successful in the past, e.g., task analysis and selection, ordering of behavioral objectives into hierarchies, selection of appropriate instructional methods and media, and organization of instructional units into meaningful sequences. But these important elements of SAT would have to be even more explicitly formulated in the new system if military personnel were to function optimally as subject matter experts under the direction of an instructional design professional, where this group would operate as a team. Indeed, the primary user of the new system would be this team, and the system should be designed to serve as a guide for team development of instructional programs.

As the present decade reached its midpoint, these considerations for a new system became crystallized into a formulation designated Instructional Systems Development (ISD), a title reflective of both the breadth and pragmatics of this new orientation. The particular formulation that emerged during this period from the ISD group at NAVTRAEQUIPCEN -- the NAVAIR/NAVTRAEQUIPCEN model -- epitomized the many developments in large-scale instructional design that spanned nearly three decades. Construction of the NAVAIR/NAVTRAEQUIPCEN model benefited from the psychological and educational expertise of several independent contractors, most notably Courseware, Inc. of San Diego, California, Calspan Corp., Buffalo, NY, Grumman Aerospace Corp., Bethpage, NY, Mathetics, Inc., San Diego, California, Logicon, San Diego, California, and Seville Research Corp., Pensacola, Florida.

Already the NAVAIR/NAVTRAEQUIPCEN model has been widely applied throughout Naval aviation in the development of a variety of training programs (F-4, EA-6A and EA-6B, A-6E, F-14, E-2B and E-2C, SH-2F, P-3, S-3, and F-18), and the model has undergone several revisions in response to feedback from these applications. This inherent modifiability, and the scope of the model's applicability, are indicative of the dynamic nature of the NAVAIR/NAVTRAEQUIPCEN model. It has the capacity to evolve as the diversity and complexity of its applications increase.

OVERVIEW OF THE NAVAIR/NAVTRAEQUIPCEN MODEL

As illustrated in figure 1, the model has been divided into five blocks of related activities beginning with Analysis and ending with Quality Control.

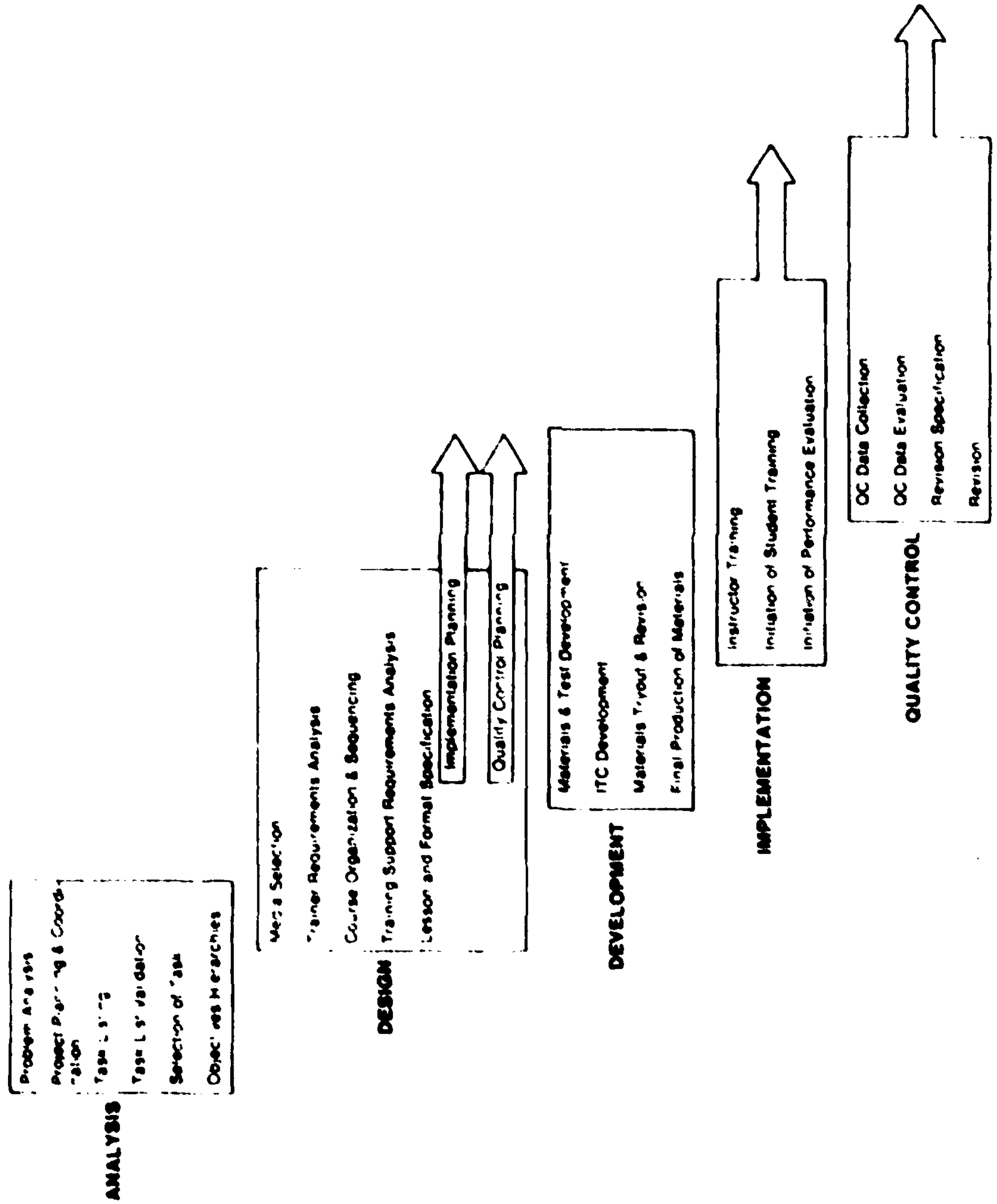

Figure 1. Major Tasks

The specific tasks to be accomplished by the ISD team are listed in the order of their occurrence within each major block. These tasks, and the rationales for their inclusion in the model, are discussed in some detail in Section II of this report. The purpose of the present section is to focus attention on the general features of the model so that the particulars to follow will be seen in their proper perspective as the functional parts of an integrated system.

ANALYSIS. The initial effort presented in the model is Analysis. This state calls for analysis of both the training problem and the behavior to be trained. This process involves a thorough study of the weapon system under consideration in order to identify the tasks that must be performed to operate, or maintain, the system. Ultimately, these tasks are translated into the component behaviors that require training. The output from this stage of ISD is a complete specification of the behavioral objectives that the new training program will be designed to achieve.

DESIGN. The second major phase of activity called for in the model is Design. It is here that the ISD team must select instructional media, specify the organization of lessons and courses, integrate ground school instruction with "hands-on" training in simulators and actual aircraft, and identify the sources of support that will be required to carry out the indicated instruction. Initial planning of implementation and quality control procedures also is begun at this point. The primary output from the Design phase of ISD is a skeleton framework of the training program that will be required to achieve the objectives determined during Analysis.

DEVELOPMENT. It is in the third phase of ISD that the program skeleton undergoes Development. The materials to be used in ground school for both study and evaluation are developed to meet the specifications for each lesson segment that were laid out during the Design phase. These materials are then tested for effectiveness in small-scale tryouts, revised if necessary, and then put into final production. In addition to development of instructional materials for students, materials are also developed that will be needed to train instructors in all facets of the new program. The output from this stage is a complete instructional package that is ready to be implemented.

IMPLEMENTATION AND QUALITY CONTROL. The fourth and fifth major phases of activity stipulated in the model are Implementation and Quality Control. The former takes the ISD team through the steps necessary to ensure that the training program will be successfully put into effect. The latter specifies the procedures to be used by the ISD team to develop a quality control system that will serve as a management tool throughout the life cycle of the program, the vehicle through which the program will be self-monitoring and corrective.

The flow of activities from <u>Analysis</u> to <u>Quality Control</u> is a logical and practical progression. Design of a new training program naturally follows from an analysis of the situation for which the program is being designed. Development of the program from the schematic stage to the full operational stage must be controlled by design. Likewise, only a fully developed program can be successfully implemented, and then only if the procedures, resources, and personnel essential to its functioning are made available and properly utilized. Finally, it is the operations of the functioning program that require quality control procedures to assure that it is meeting design specifications and that it will continue to be effective in training the behaviors identified during the analysis phase of ISD.

SECTION II

DESCRIPTION OF THE NAVAIR/NAVTRAEQUIPCEN MODEL

Whether the NAVAIR/NAVTRAEQUIPCEN model is applied to a newly emerging weapons system, or to an existing system, the ISD process is initiated by a documented indication of a need for a new training program or a revision of an existing system. This initial documentation identifies the nature, scope, and criticality of the training project. If it is found to be of sufficient magnitude to warrant further consideration, an in-depth problem analysis is planned by NAVTRAEQUIPCEN. After the plan has received the approval of NAVAIRSYSCOM, and the lines of communication have been established among the various participating Navy organizations, a full-scale problem analysis is launched under the direction of the ISD group.

The primary objective of the problem analysis is to establish the precise nature of the training effort that will be required to achieve an effective instructional program. In the case of an existing training program, every aspect of the system is examined and evaluated in order to identify the needed revisions and the appropriate strategies for making them. The analysis would include everything from instructional syllabi, training materials and devices, tests and student attitudes to management efficiency, and instructional goals of the existing system.

In the case of an emerging weapons system, the analysis is directed toward a preliminary determination of the tasks required to operate the system, the kind of training program, materials, and devices that will optimize student learning of the required tasks, and the structure of the Navy organization that will be needed to develop, implement, and manage the instructional system. In the case of either an existing or an emerging system, the problem analysis identifies the personnel, facilities, equipment, time, and costs required for development and implementation of the needed training program. This information is evaluated relative to program goals and assets, and a Problem Analysis Report (PAR) is prepared. A sample outline of the PAR contents for an existing system is shown in figure 2.

If the projected goals and requirements of the needed training program, as documented in the PAR, are approved by NAVAIRSYSCOM, then development of a program master plan (PMP) is undertaken by the ISD team.

The PMP serves as a tool for managing and coordinating the ISD project, and it incorporates the information contained in the previous problem analysis together with other information such as the latest funding analyses available and cost data from previous ISD projects. The ISD model is also taken into account in the PMP since the model delineates the stage-by-stage progression of ISD and stipulates the products generated at each stage. All this information is integrated by the ISD team and the PMP is formulated.

The PMP states the objectives of the proposed ISD program, and the procedures by means of which those objectives can be realized. The major milestones of the ISD project are specified, and a method is provided for tracking the various stages of the development process. The resources and facilities required for the ISD project are inventoried together with the sources committed

I. Introduction

A. Purpose and scope of the problem analysis.
B. Data collection methods and sources.
C. Status and previous decisions relative to the FRS aircrew training program or maintenance training program enhancement efforts.

II. Training Program Data

A. Program goals.
B. Training organization and user commands.
C. Instructional staff.
D. Student population.
E. Curriculum description.
F. Training equipment, aircraft, and facilities.
G. Existing curriculum deficiencies and training problems.
H. Usable training assets.
I. Conclusions and recommendations.

1. Existing program deficiencies.
   (a) Curriculum.
   (b) Training equipment.
   (c) Facilities.
   (d) Organization.
   (e) Instructional staff.
2. Training asset deficiencies.
   (a) Personnel (instructional or subject matter experts)
   (b) Printing, photo, drafting, etc.
   (c) Facilities.

Figure 2. Analysis: Problem Analysis (Problem Analysis Report Outline for Existing Systems)

to making them available. The plan also stipulates the organizational roles and responsibilities of participating organizations and personnel, and provides a system for their coordination. The plan even designates the specific jobs to be performed throughout the ISD project, and indicates when each job is to be performed, and by whom. The plan also identifies potential funding sources, gives cost estimates for each of the successive stages of the ISD project, offers various procurement strategy options, and describes the materials needed to carry out appropriate procurement procedures. Thus, the PMP serves as the primary management tool for directing the development of a large-scale instructional system. A sample outline of PMP contents for an existing system is presented in figure 3.

If the PMP is approved by the NAVAIRSYSCOM, the project may then move ahead into the more detailed task analysis stage where the real job of behavioral specification and instructional design begins.

It is in the analysis phase of ISD where the techniques of modern psychology and instructional technology are applied most intensively in the model. The complexity of the machines that men must be trained to operate and maintain, especially airborne weapons systems, requires an approach to training that is based in the science of human behavior and the allied technology of educational systematics.

The fundamental principles of these disciplines have been incorporated into the model in a manner that is uniquely adapted to the needs, resources, and constraints present in Naval training situations. In part, the unique applicability of the model stems from the management system it has built into the ISD process, and it is through the application of behavioral and educational principles that the model becomes, at once, both an adaptive and a powerful tool for solving the huge and complicated training problems encountered by the modern Navy.

The analysis phase of ISD begins with the question, "What are the tasks that must be performed in order to operate the system in question, and, under what conditions must these tasks be performed"? The answer to this question is obtained through a <u>task analysis</u> of the operational system.

First, system operation is partitioned into the major job responsibilities required for each mission phase. Then, each responsibility area is further analyzed to identify the primary task components that must be performed. Each task component is described in a detailed and standardized fashion. A task description states precisely the conditions under which the task is performed, the actions that compose the performance, and the particular outcomes of the performance. This emphasis on task identification and description is based on the psychological principle that "the more accurately a behavior can be specified, the more efficiently it may be trained." Thus, task analysis generates task specifications, i.e., descriptive statements of the conditions, actions, and outcomes that compose each task component. By organizing these task descriptions according to responsibility areas and mission phases, an accurate picture of the behavior required to perform a job is obtained. In this case, the job description is a <u>task listing</u>. A model of the task listing procedure is illustrated in figure 4 and a partial task list from the EA-6B program is given as an example in figure 5.

I. Introduction
   A. Purpose and Scope of PMP
   B. Program Background
   C. Program Objectives

II. Organization, Roles, and Responsibilities

III. Overview of Program Phasing, Activity, and Assigned Responsibility
   A. Detailed Phase Plan (only for Imminent phases)
   b. Schedule
      --Proposed Activity Schedule (for imminent phase only)

IV. Plans

V. Resource Commitments

Figure 3. Analysis: Project Planning and Coordination (Program Master Plan Outline for Existing Systems)

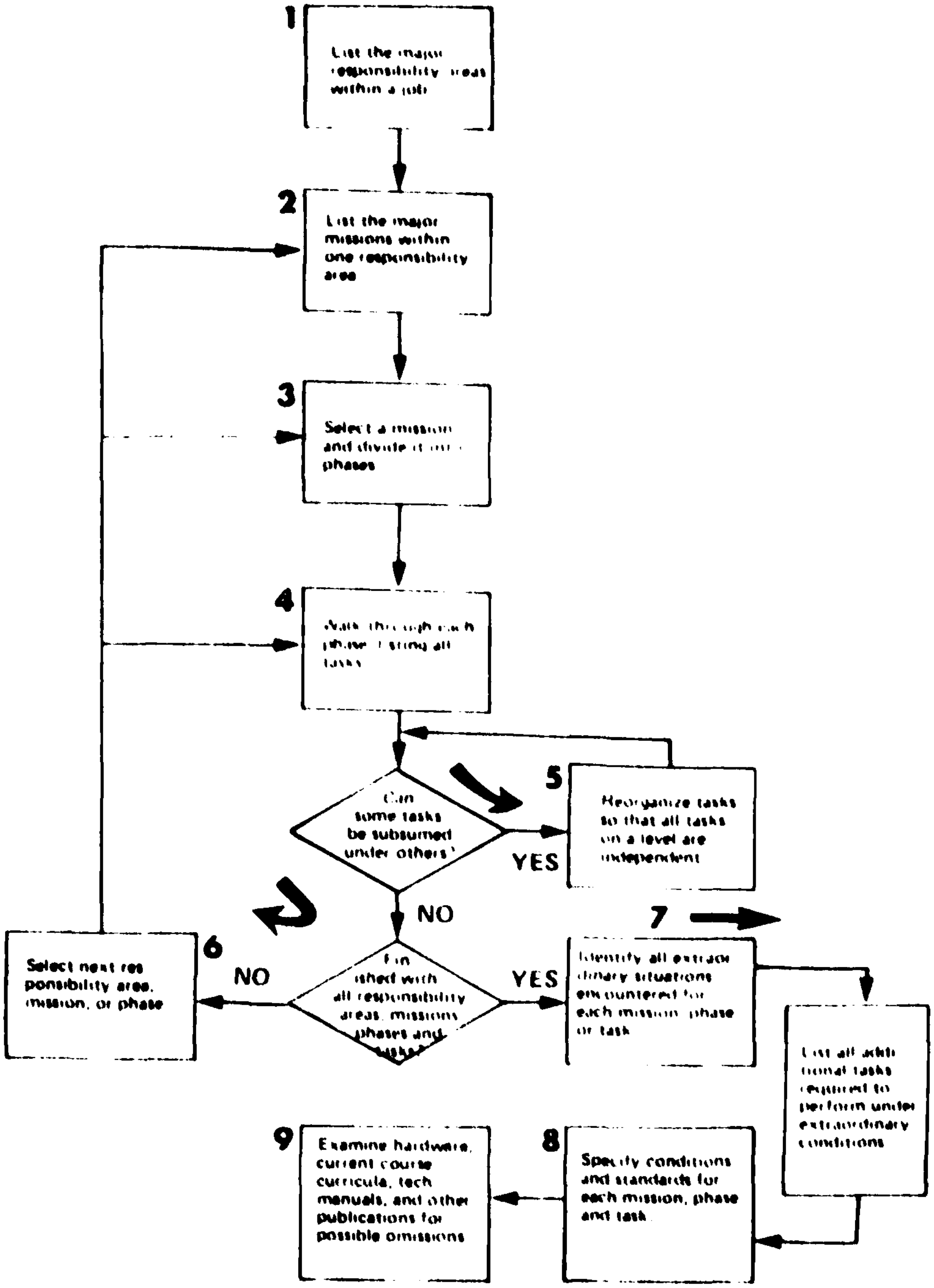

Figure 4. Analysis: Task Listing
(A Task Listing Model)

TASK	CONDITIONS	STANDARDS
1 Inspect and don flight gear	Given appropriate flight gear	100%
2 Review VIDS cards	Given all past VIDS cards, SOP, NATOPS and maintenance publications	Review minimum of past 10 flights
3 Conduct physical preflight of airframe and cockpit	Given mission designated A/C	100% in less than 15 minutes
4 Strap in	Given A/C and properly donned flight gear	5 minutes
5 Set up cockpit prior to addition of power	Given A/C ready for flight and PCL	Less than 5 minutes
a. ECMO No. 1 set up cockpit	Given A/C and PCL	Less than 5 minutes
1 Check oxygen	Given mission ready A/C, PCL	100%
2 Ensure vent air cushion airflow is off	Given mission ready A/C, PCL	100%
3 Check KY 28 No. 1 and No. 2 off	Given mission ready A/C, PCL	100%

Figure 5. Analysis: Task Listing
(A Sample Partial Task List, EA-6B)

The task analysis and listing process is usually carried out by a team of subject matter experts (SMEs), Navy personnel experienced in the operation of the weapon system under consideration, who have been trained in ISD methodology by a behavioral specialist. Together, the specialist and SMEs form the ISD team responsible for producing the initial task listing. To ensure that the task descriptions are accurate, and that the task listing is complete and properly organized, an independent group of SMEs evaluates the work of the original ISD team. They also estimate the frequency and criticality of performance of the individual tasks. This step in the ISD process is referred to as task validation, and it may result in a revision of the original listing. As a means of standardizing the validation procedure, the ISD team prepares a questionnaire which the independent group of SMEs uses to evaluate the task list. A sample questionnaire form used in the EA-6B program is shown in figure 6.

Now that the tasks have been behaviorally specified and functionally organized, the validated task listing is subjected to another kind of evaluation. Each task in the listing is examined systematically by the ISD team in order to determine the level of training that it will require.

Depending on the entry-level skills of the new FRS trainees, as compared with the standards of acceptable performance for individual tasks, the ISD team will assign each task to one of five different training categories. These five categories are; full-scale, review-only, familiarization-only, deferred, and no-training required. For example, if a given task has to be performed frequently, and if its performance standard exceeds the entry-level skills of trainees, the task would be scheduled for full-scale FRS training, especially if correct performance of the task were critical. On the other hand, even a high-frequency task might be classified as requiring no training if its performance were already well within the entry-level skills of the new trainees. A model of this decision-making process is presented in figure 7.

As a result of this careful procedure of task selection, a major benefit is achieved. Resources and time are not wasted on unnecessary training, and tasks that are essential to competent performance are not overlooked in the training program. Rather, the approach taken is to assign each task to just that level of training which is necessary to assure that its performance will at least meet the operational standard.

At this point the tasks selected for FRS training are reviewed to determine which of them must be trained in either real, or simulated, operational environments. Tasks that require live enactment or perceptual-motor skills involving realistic visual, auditory, motion, etc., cues are designated for "hands-on" media training. This group of tasks is further divided into two categories; those that must be trained only in actual flight conditions (or only on actual operational equipment), and those that can be trained under synthetic operational conditions. It is the latter group of hands-on tasks that are of interest at this stage of the ISD process.

Analysis of the conditions and standards associated with these tasks enables the ISD team to arrive at a definition of the kinds of training devices that will be needed for simulated hands-on training. The attempt here is not only to select the most suitable training medium for each task, but to identify

TASK	How often do you perform this task as a part of your flight?					How soon after leaving VAQ 129 training did you have to perform this task?			Where did you first learn to perform this task?							How critical is this task to mission accomplishment?			
	More than once per flight (specify)	Once per flight	Most flights	Few flights	Never	During pre deployment	During first deployment	After first deployment	Didn't learn	Prior to VAQ 129 training	During VAQ 129 training	Pre deployment squad training	Post deployment squad training	Learned on your own	Other	Highly Critical	Moderately Critical	Somewhat Critical	Not at all Critical

Figure 6. Task List Validation Questionnaire (Sample from EA-6B)

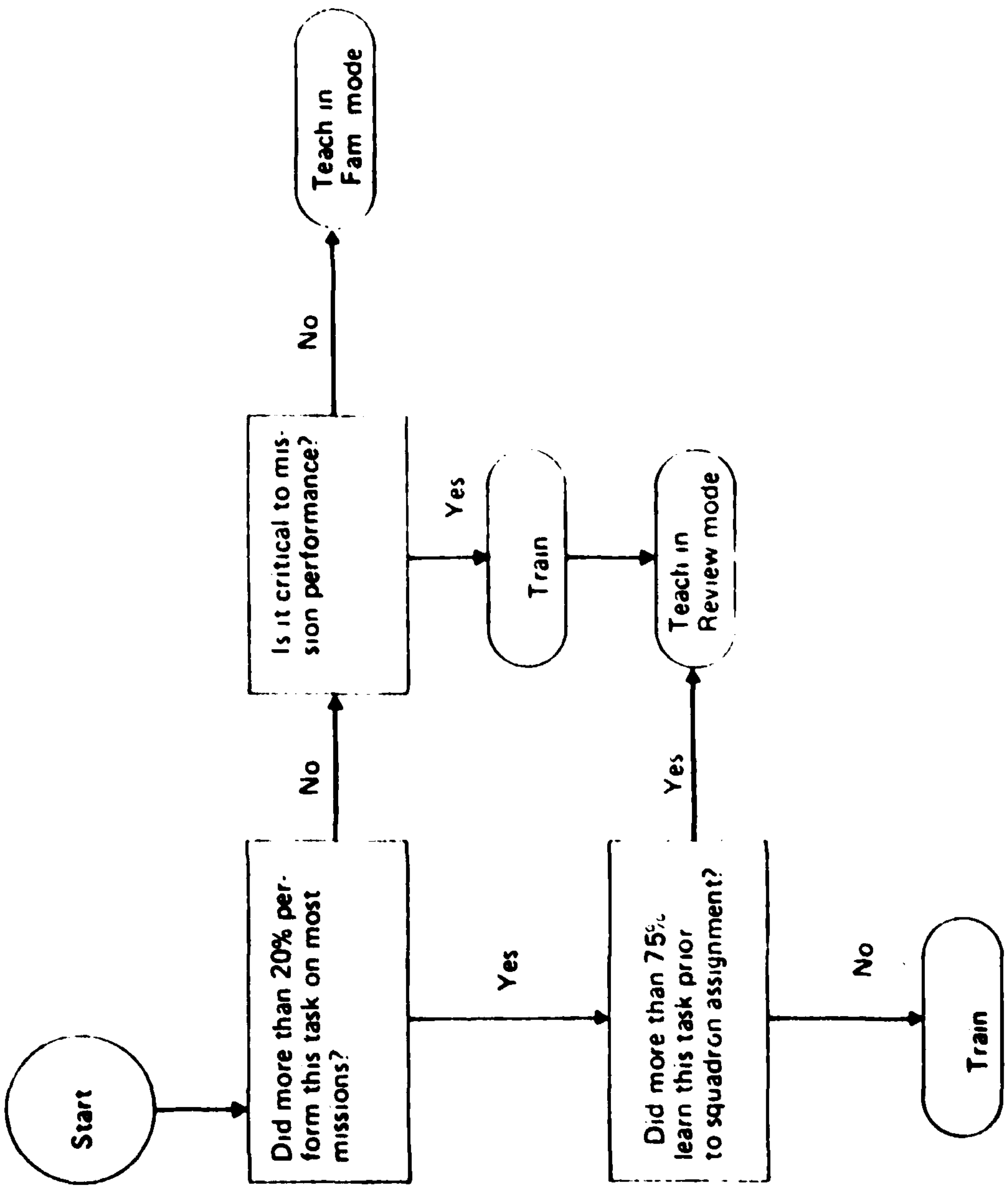

Figure 7. Analysis: Selection of Tasks for Training (A Task Selection Model from EA-6B)

as early as possible those media which are expensive and require time for design and production. This important feature of the model permits parallel development of both the training program and the systhetic training media, thus avoiding costly delays in implementation.

The armed services have long recognized that training devices are less expensive to use as training media than actual operational systems. The savings in personnel time and fuel consumption alone are sufficient to warrant their use in training programs. But it has also been recognized that synthetic devices enable the training of many procedures (such as those involving emergencies) that could not otherwise receive any degree of instructional attention. However, the approach taken by the model extends the advantages of training devices even beyond this level of utility.

In the model, behavioral objectives of the instructional program control training device specification. This concept is in marked contrast with the old notion that a training device should simulate the operational system as closely as possible. To the surprise of many, a training device optimally designed to meet behavioral objectives may involve considerably less simulation than those produced by the traditional approach to training. Furthermore, where device specifications are governed by behavioral objectives, the devices are not only more effective as training media, but they may be less expensive to produce and operate. Since just that degree of simulation that is necessary to adequately train tasks is incorporated into a device, the expense of unnecessary simulation is avoided. Training devices designed to the specifications generated from the ISD approach are effective for minimal cost. It is significant that these devices are designed to be an integral part of the overall training program, to serve as instructional media with specific training objectives. This assures an extensive utilization of available devices and, consequently, the realization of a higher return on the Navy's investment.

What we have seen up to this point in the ISD process is a systematic analysis of the behavior necessary to operate a weapons system. For each operator position, the necessary behavior is broken down into its component tasks, and these tasks are organized into its component tasks, and these tasks are organized into the functional units that occur within each phase of a mission. The task listing is independently validated, and, if necessary, then revised. The conditions, outcome, frequency, standard, and criticality of performance of each task is specified. These factors, together with an assessment of entry-level skills of new trainees, provides the data needed to select the tasks to receive FRS training and to designate the type and level of training required for each task. Hands-on tasks that can be best trained in synthetic devices are identified, and this enables an early specification of the training devices that will become an integral part of the training program.

While the analyses of behavior carried out thus far are adequate for task specification and selection, an even finer analysis is necessary to determine the nature of the behavioral objectives that the training program must be designed to achieve.

The distinction between tasks and behavioral objectives is fundamental to the ISD methodology, for it is the objectives that control the detailed aspects of instructional design. It may be said that, whereas, tasks are what a person must do to operate a system, behavioral objectives are what a training program must achieve to produce competent task performance.

The behavior required to perform a complex task always contains a number of component skills, concepts, decision-making strategies, etc. Consequently, whole-task performance cannot be trained satisfactorily until its more basic components have been learned. For example, the use of an on-board computer to calculate the time-of-arrival at some distant destination requires that the operator not only possess the fundamental computer skills, but he must also have knowledge of the more general navigational principles and techniques, as well as the basic mathematical skills essential for numerical computation. Use of the on-board computer and applications of navigational principles could not be taught effectively if the trainee did not first possess the elemental mathematical and computational skills.

So, by breaking down a task into its fundamental components, and by comparing these with the skills already present in the behavior of the new trainees, it is possible to identify the particular behavioral components of a task that must be individually trained. These task components become the behavioral objectives to be achieved by the training program.

This analysis of the behavior required to perform a task, however, only yields a set of target behaviors that the ISD program must be designed to produce in trainees at criterion proficiency levels under specified conditions. These target behaviors, or behavioral objectives, may be many steps removed from the basic entry-level skills of the trainees. Thus, the behavioral components intermediate between entry-level skills and target behavior also must be enumerated.

Again, the driving principle behind this progressively more detailed analysis of behavior is to make explicit that which must be trained. Intermediate behaviors are prerequisites for target behaviors in the same sense that target behaviors are prerequisites for task performance. The relationships among intermediate behaviors and target behaviors form an organizational hierarchy shaped like a pyramid with the behavioral objectives located at the top. Behaviors listed at each level of the objectives hierarchy are always prerequisite and essential to performance of the behaviors listed at higher levels in the hierarchy. A model of the hierarchy analysis process is presented in figure 8.

Construction of objectives hierarchies is a crucial step in the ISD process for several reasons. First, the construction procedure helps to ensure that the ISD team will not overlook any important intermediate behaviors, second, the hierarchical organization of the intermediate behaviors leading to each behavioral objective shows the sequential order in which these behaviors should be learned, and third, the entire subject matter content of the instructional program is delineated in the hierarchical organization of the behavioral objectives. Thus, objectives hierarchies provide a complete picture of the diversity of behaviors, and their interrelationships, that must be encompassed by the instructional system. A sample objectives hierarchy is illustrated in figure 9.

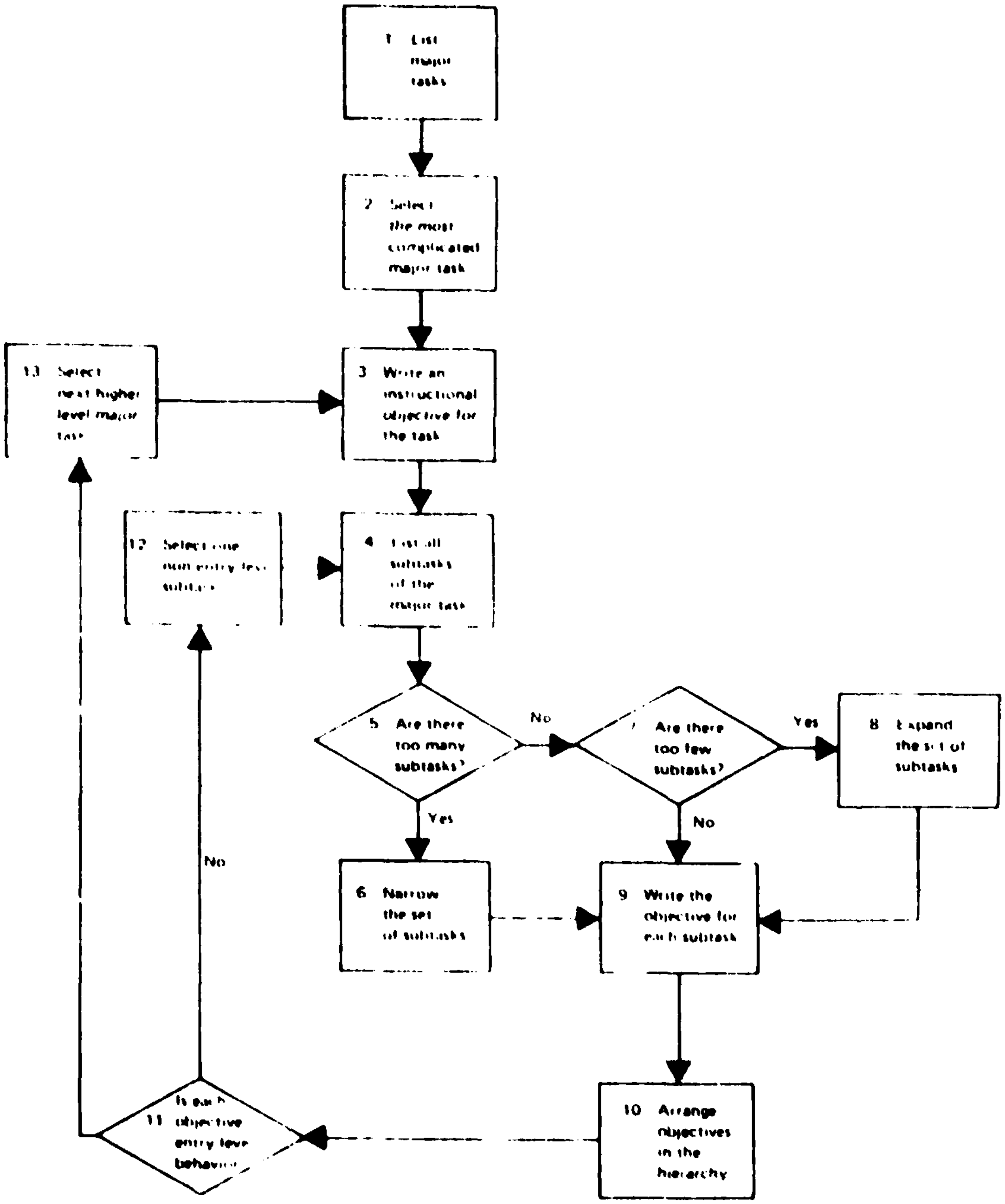

Figure 8. Analysis: Objective Hierarchy Development
(A Hierarchy Analysis Model)

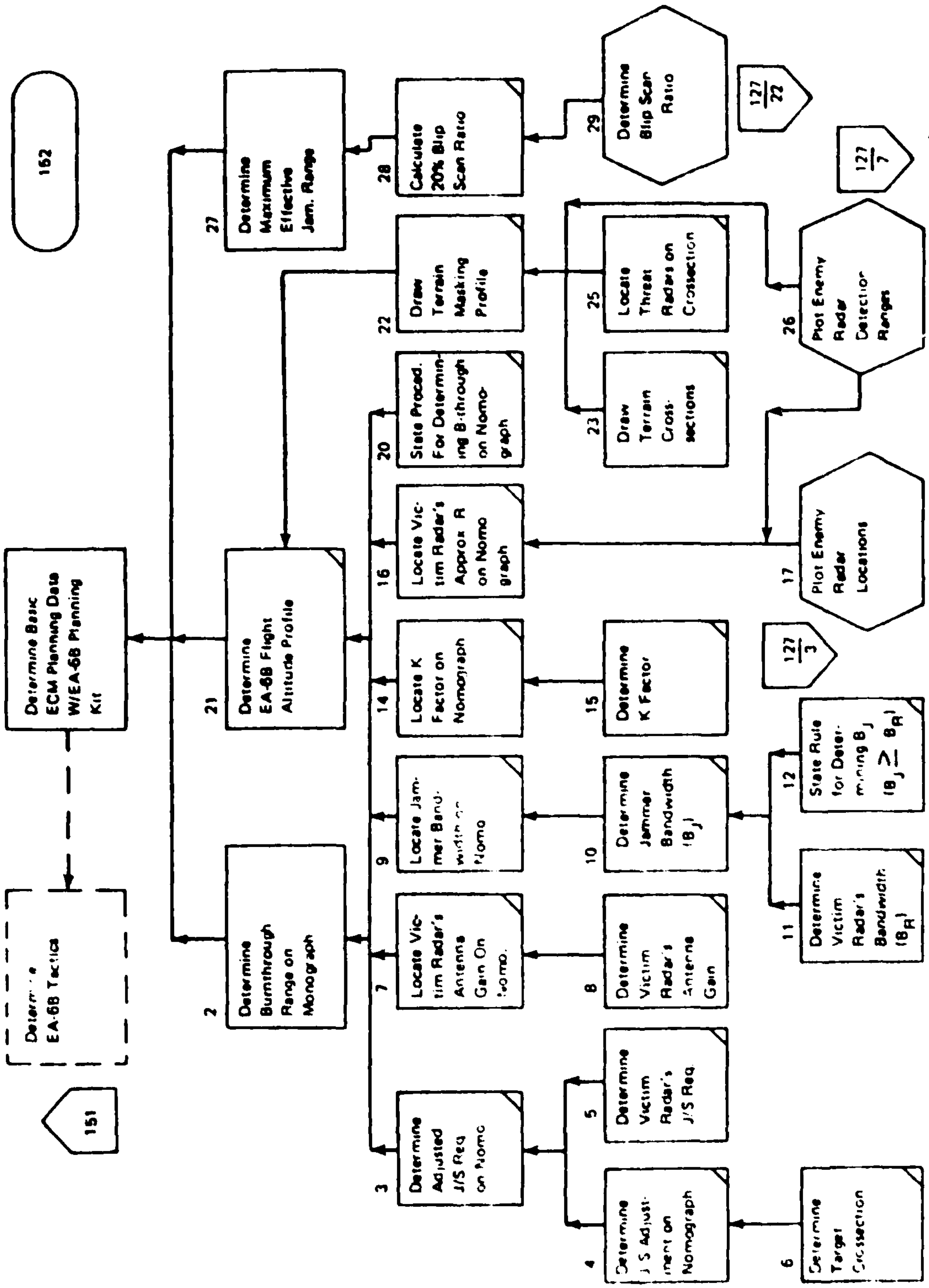

Figure 9. Analysis: Objectives Hierarchy Development (A Sample Hierarchy from EA-6B)

Now that the question of what to teach has been definitely answered, the next question to be addressed is how to teach it most effectively? An answer to this question must be obtained for each behavioral objective, and each answer must identify both the method and medium for instruction that will optimize student learning of the behavior.

Knowing what to teach is usually not synonomous with knowing how best to teach it. For this reason, the model provides the ISD team with a special decision-making procedure which can be used in a straightforward manner to select methods and media given certain inputs to the process. As illustrated in figure 10, the ISD team first determines the resources that will be available for instruction, i.e., the funds, personnel, and facilities. These resources set limits on the range of methods and media from which the team may select. After this is established, the ISD team looks at the subject matter content of each behavioral objective to ascertain the kind and level of learning involved, the level of competency students will be expected to obtain, the kinds of interactions with instructors and materials that will be needed to substantiate and motivate learning, the specificity and source of response-contingent feedback necessary for self-corrective learning, and the characteristics of information displays essential for effective presentation of the subject matter. When this information has been obtained, the ISD team is ready to begin the decision-making process that will result in the optimal choice of an available method and medium for each particular subject matter under consideration. In practice, the complexity of media selection can be reduced to an algorithm such as that shown in figure 11. This model provides a systematic sequence of steps that begin with a behavioral objective and end with an appropriate selection of instructional media.

Advances in the application of electronics to the development of instructional media has had a profound influence on educational technology. This is especially evident in some of the applications of computer science. Consider, for example, the sophisticated visual and auditory displays now utilized in modern instructional media and simulation devices, the advanced computer programs that allow for student interation and provide response-contingent feedback, and the many kinds of information processing systems that extend the limits on man's memory and thinking capabilities.

No longer must the quality of instruction be invested primarily in the expertise, ability to communicate, and motivating influence of the traditional instructor. The diversity of methods and media existing today permit the instructional designer to choose the one that is most appropriate for each behavior to be trained. Furthermore, the new methods and media rely less on the instructor operating as a lecturer, motivator, and evaluator. In ISD programs, instructional presentation and evaluation is individualized, and motivation is maintained through reinforcing contingencies built into the progression of events each student encounters as he moves through the program. This shifts the responsibilities of instructors and students from those of lecturer and pupil to those of guide and learner. The respective role of each is enhanced, as is their motivation to perform well. The new responsibilities of instructors and students in the training program designed according to the NAVAIR/NAVTRAEQUIPCEN model are largely due to the methods and media selected for use, but they are also dependent upon the way instructional courses are developed and sequenced.

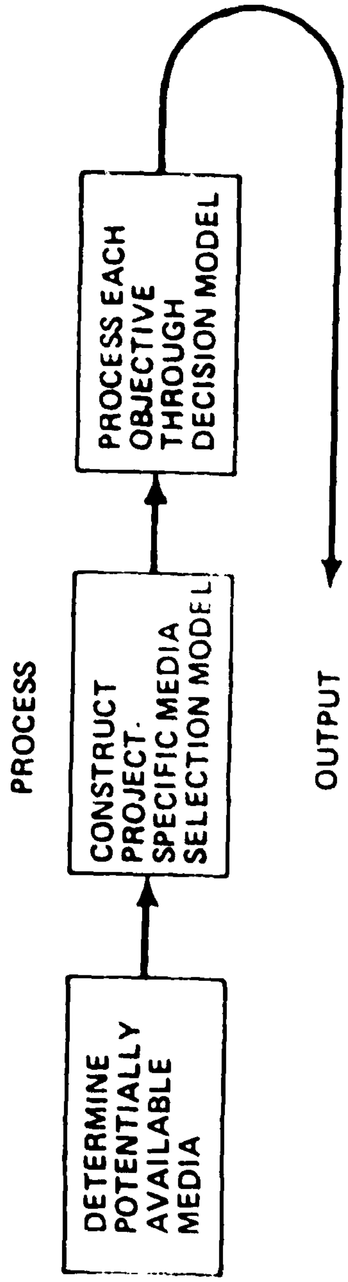

Figure 10. Design: Media Selection - List of Instructionally Acceptable Media for Each Objective

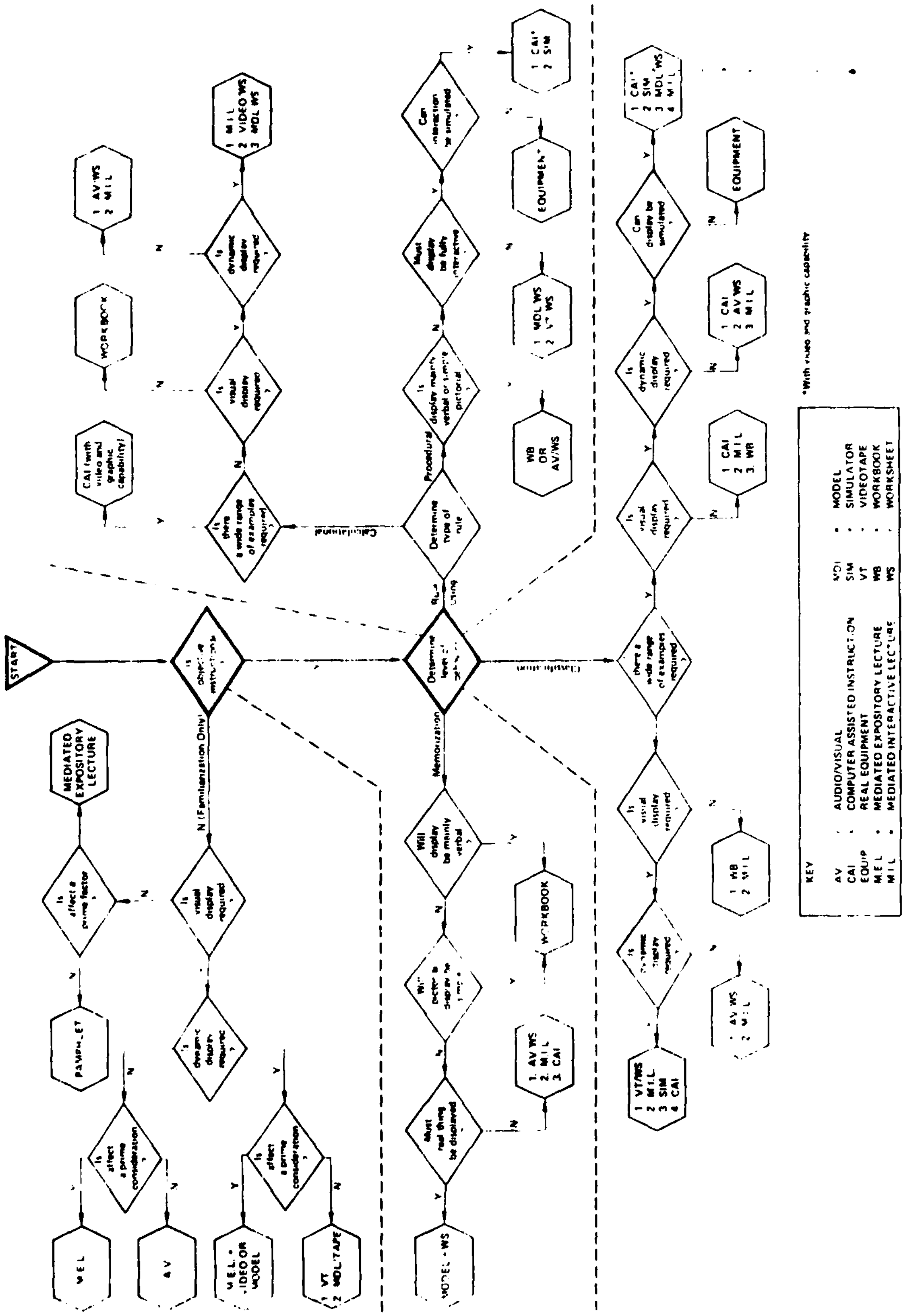

Figure 11. Design: Media Selection (A Sample Media Selection Model)

The sequence of instructional experiences through which the students move in an ISD training program is stipulated in a course syllabus, a kind of map in which behavioral objectives are organized into lesson sequences. A given course is divided into major units of instruction, and each unit consists of a number of lessons which are further broken down into individual segments. These divisions of a course are sequenced to lead onto each other such that the student is moved in a steady path from lower to higher order knowledges and skills.

The progression of learning experiences is arranged so that the student's knowledge and skills build in increments small enough to never overextend the students' capability, but large enough to ensure an optimal rate of progression from entry levels to the more complex job levels of performance. This kind of arrangement is designed to prevent failure at one point in a course due to incomplete experience gained at previous points in the course. At each stage, the student has all the experience he needs to proceed successfully to the next stage.

Instruction programmed in this fashion has proved to be a far more efficient approach than the traditional one because it not only reduces failure to a minimum, but it also produces a high level of student motivation. When effort-to-learn results in success, this feedback motivates the student to continue. Thus, the sequential ordering of learning experiences into well-designed course syllabi is a crucial aspect of the ISD process. It is at the stage of syllabi development that the ISD team moves from behavioral analysis to instructional design, incorporating the information contained in the objectives hierarchies into a framework designed to maximize learning.

The transformation from objectives hierarchies to course syllabi is nearly as complicated as it is important, and ISD team members require some training and expert guidance in this process. Essentially, the question they must answer is "into what sequences must the behavioral objectives be ordered?", and this question must be answered for each behavioral objective.

Usually, the position of a behavioral objective in its hierarchy will determine its sequential position in a course syllabus. Objectives located at the bottom of a hierarchy are more elementary than those above them and, thus, should be taught first. However, if all low-level objectives were taught before moving up the hierarchy, the student would tend to become bored and possibly even forget some of the information he has already learned because he would not have had an opportunity to apply it. So, this problem is avoided by introducing hands-on experience into the syllabus as soon as possible. Generally, this can be accomplished by limiting successive sets of objectives to vertical legs of the hierarchy. In other words, the designer starts with the lowest objective on one vertical leg and moves up to the point where a hands-on objective is encountered. The latter may be anything from a familiarization exercise in a trainer to an actual flight in an aircraft. This type of sequence cycles the student from purely ground school type situations to equipment exercises, then back to ground school for more basics followed by further equipment exercises. A flow diagram of the course organization and sequencing process is shown in figure 12.

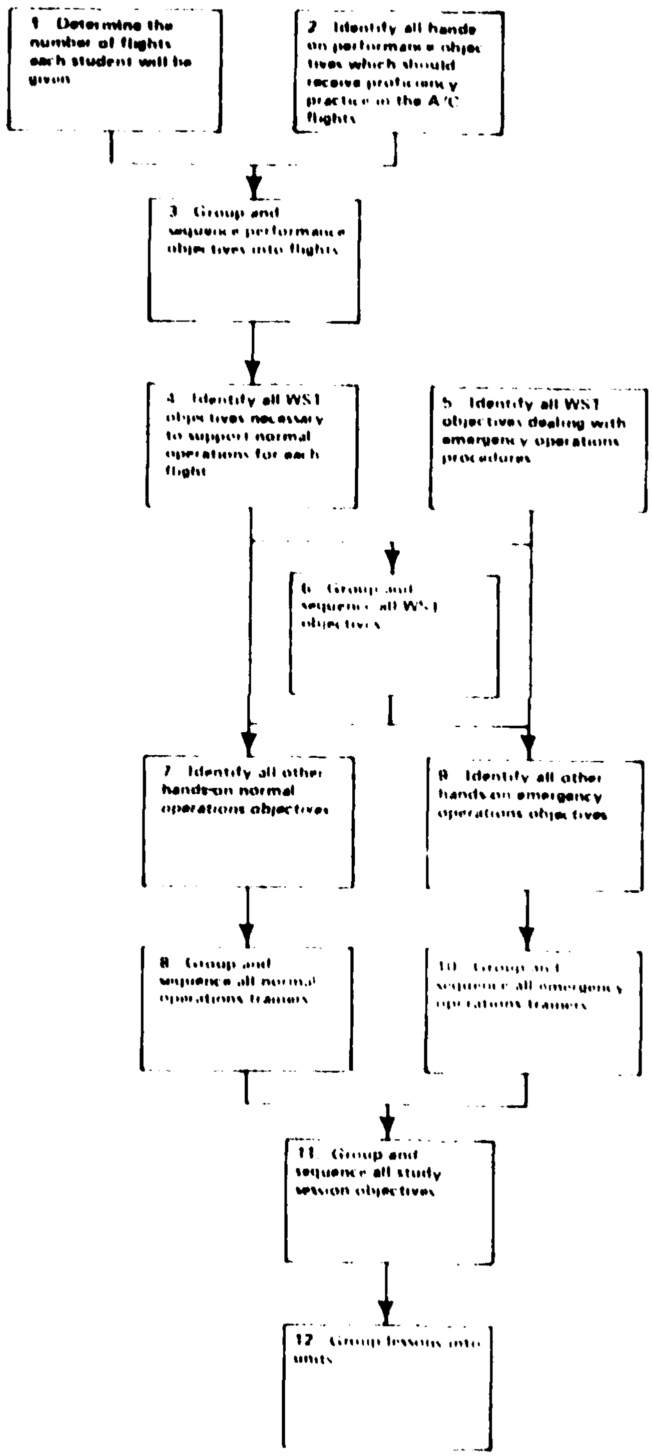

Figure 12. Design: Course Organization and Sequencing (The Organization and Sequencing Process)

This type of cycling maintains the integrity of the objectives hierarchy while allowing the student to practice his newly acquired skills as soon as possible. In this way, a small portion of the syllabus is encountered, learned, and practiced before the student moves on. Those objectives requiring actual flight in the aircraft are preceded by objectives of a more elemental nature that are practiced in a trainer or simulator. The objectives prerequisite to trainer exercises are still more elemental and they constitute the content core of ground school instruction. Typically, the student would go through several evolutions of the cycle between ground school and trainer exercises before cycling up to an aircraft flight, and the objectives to be accomplished in the first aircraft flight would be less difficult than those scheduled for later flights. At each stage in the syllabus, the student is prepared to advance to the next stage.

Segment-by-segment, the ISD team organizes related behavioral objectives into lessons. Elemental lessons are placed ahead of more difficult ones in the syllabus, and a test is scheduled for each lesson. The lessons that pertain to a given subject matter are organized into instructional units, and an equipment exercise is scheduled at the end of each unit. Finally, the various units of instruction are structured into a framework that forms the course syllabus.

Not only do course syllabi serve as maps of the instructional sequences for the entire training program, but they also provide the ISD team with a sufficiently complete picture of the program to permit an accurate analysis of the new program's training support requirements. Consequently, it is at this stage that the ISD team estimates the total personnel, equipment, services, materials, and facilities that will be required to complete the development of the training program, and to implement and maintain it throughout its life cycle.

For example, the trainer specifications generated earlier during task selection are now reexamined to determine if each trainer will encompass a sufficient number of objectives to be utilized fully, and if each is the least expensive device that can be effective in training the specified objectives. Similarly, the classroom media selected earlier are now evaluated to determine which media are most feasible for presenting the information within each lesson. The answers to these questions enable the ISD team to estimate the purchase, modification, production, and operating costs required for the various trainers and instructional media. However, in order to estimate personnel, services, and facilities requirements, the ISD team must construct a daily time-based class schedule for all courses in the training program. From this, the team can establish the student flow throughout the program and the support requirements on a lesson-by-lesson basis. The major steps involved in training, support requirements analysis are illustrated in figure 13.

Training support requirements analysis provides the information needed by planners and managers to assure the availability of critical support resources needed for satisfactory completion of the training program and its ultimate implementation and maintenance. By basing this analysis on completed course syllabi, a major source of potential program failure is avoided, i.e., failure due to the unavailability of some key instructional resource around which much

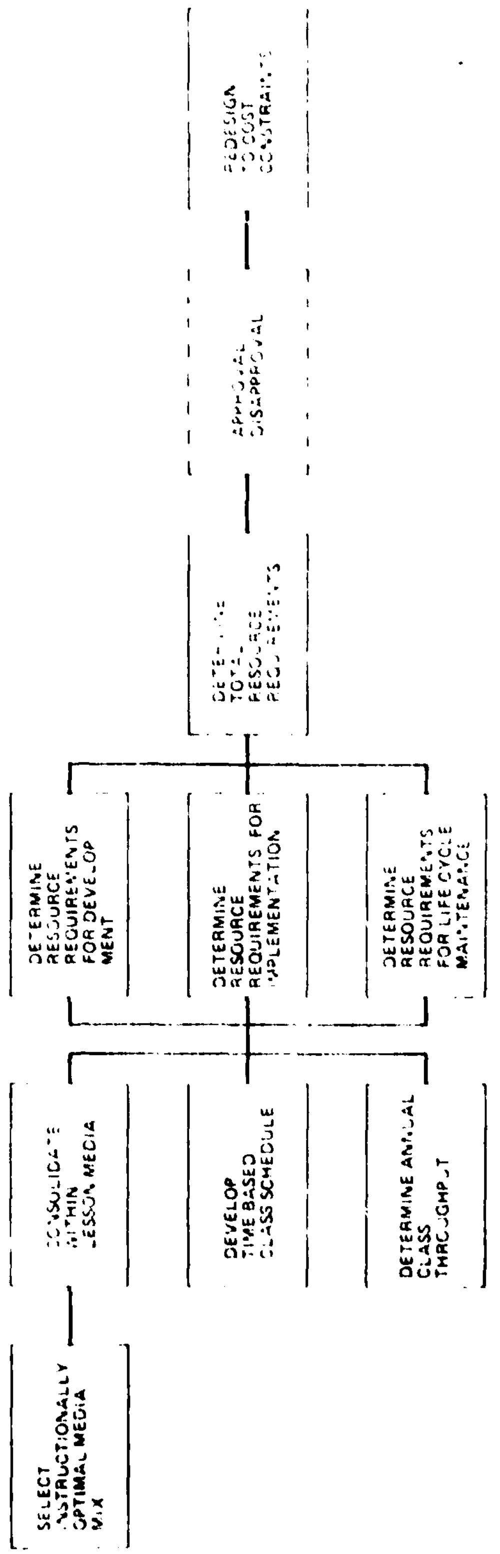

Figure 13. Design: Training Support Requirements Analysis (TSRA) (The TSRA Process)

of the training program has been designed and upon which program implementation is dependent. Rigorous support requirements planning at this stage in the ISD process ensures that only those resources available to the program are incorporated into its design.

Now that the skeleton of the program has been built and the resources needed to support it have been established, the time has come for the ISD team to put some meat on the bones, i.e., to write the lesson specifications. The critical subject content and teaching strategy must now be specified for each behavioral objective in the course syllabus. For example, if, in order to achieve a particular objective, the student must learn a rule, a definition, a fact, or a procedure, the ISD team must state it explicitly. Likewise, if a particular kind of explanation, or mnemonic aid, will facilitate learning of the objective, this also is specified. In addition, the ISD team determines the various kinds of illustrative examples, practice problems, and test items that will best exemplify and evaluate the behavior called for in the objectives. The team also stipulates the graphic illustrations to be included in the instructional material for each objective. After this has been completed for all the objectives covered in a given lesson, a lesson format guide is prepared which explains how the material in each segment will be organized, and how the individual segments will be tied together to form the lesson. A sample format guide outline for one lesson segment is presented in figure 14. The output from this stage of the ISD process is a set of tight guidelines that will be used to control the organization of the detailed subject matter content.

The guidelines help to avoid the kind of instruction which gives either too much, or too little, attention to certain materials, misses the point, or buries it in a mass of detail, or ignores fundamental considerations of teaching strategy. Proper lesson specification ensures that the principles to be learned in any group of behavioral objectives determine both the kind and degree of detail given, as well as the strategy that is chosen to teach it.

The lesson specifications and format guides provide the groundwork for actual lesson authoring. Working from the specifications of lesson contents and format, the ISD team write-out paper and pencil versions of the final instructional materials. After review and editing, these materials go into prototype production for use in small-scale tryouts with real students. Usually, these prototype instructional materials are scheduled for tryouts as they are being developed. By means of these tryouts the ISD team is able to determine whether the materials are actually effective in bringing about the desired learning, and to establish whether the materials are palatable to the students. Instructional materials that are found to be weak in either respect are revised and, if necessary, tried out again.

This procedure maximizes the probability that the instructional materials will be successful once the training program is implemented. After the materials have undergone their final revision, they are then scheduled for final production. The activities of the ISD team during this evaluation process are diagramed in figure 15, parts 1 through 4. The finished product is a package that comes as close to guaranteeing effective instruction as can be provided by modern technology. However, the NAVAIR/NAVTRAEQUIPCEN model recognizes that, in order for this training package to remain effective

Sample: **Format for Teaching a Concept or Rule Objective by Tape/Slide (TS) and Worksheet (WS)**

1. **Segment Introduction**
   a. Rationale and relation to other lessons (TS)
   b. Objective (TS and WS)
   c. Procedural directions (TS and WS)
2. **Body**
   a. Core information (TS and WS)
   b. Help (TS)
   c. First illustrative example (TS)
   d. First example help (TS)
   e. Additional example-help sequences (TS)
   f. First practice item (TS) (WS response)
   g. Feedback for first practice item (TS)
   h. Additional practice-feedback sequences (TS-WS)
3. **Testing**
   a. Testing/scoring directions (TS-WS)
   b. Test items (TS)

Figure 14. Design: Lesson and Format Specification

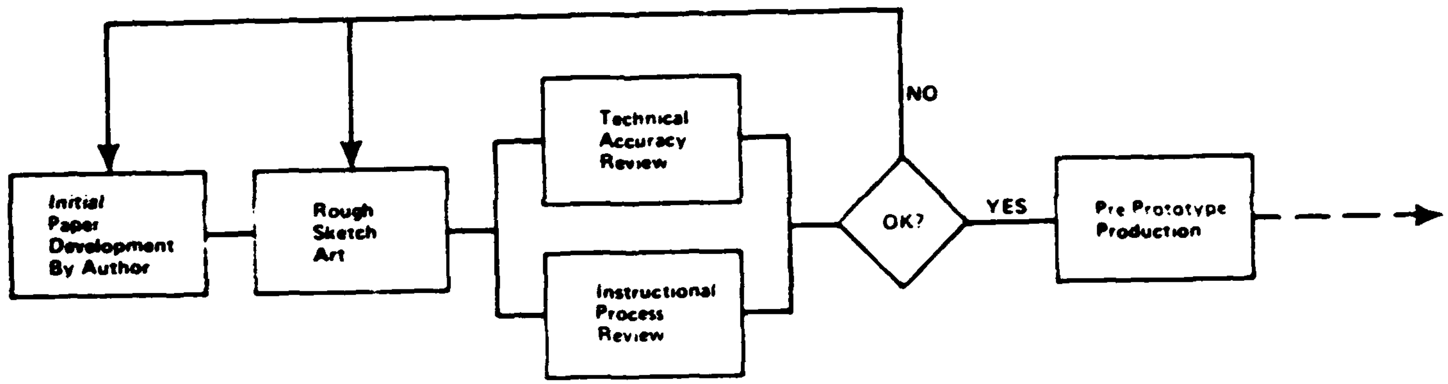

Figure 15. Development: Materials Tryout and Revision (Quality Control of Development: Paper Stage) (Part 1 of 4)

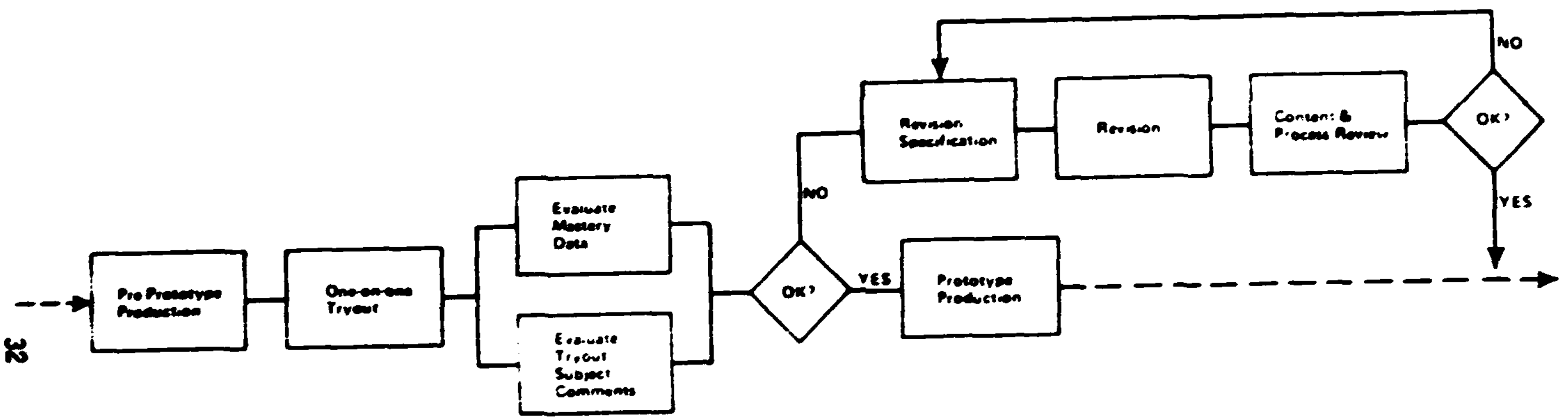

Figure 15. Development: Materials Tryout and Revision (Quality Control of Development: Pre-Prototype Stage) (Part 2 of 4)

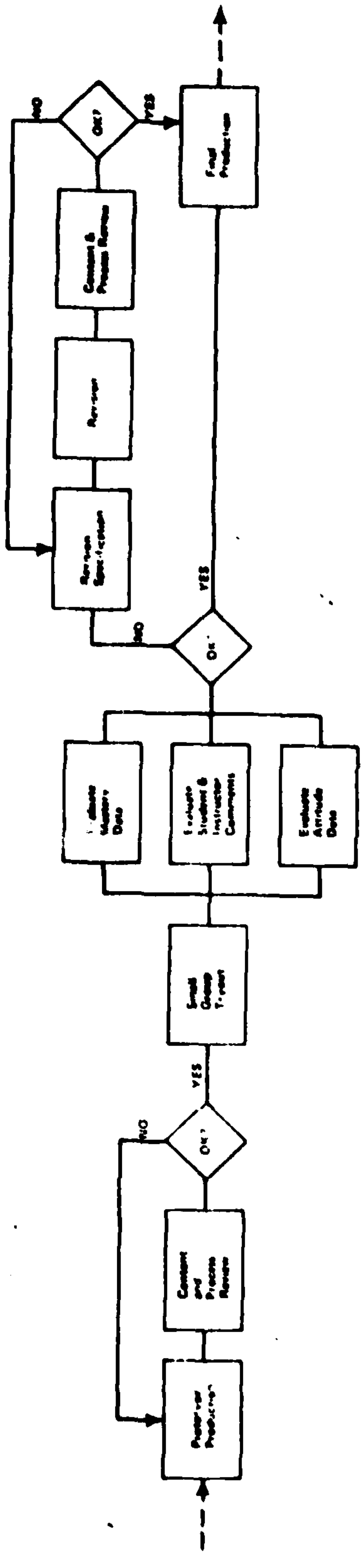

Figure 15. Development: Materials Tryout and Revision (Quality Control of Development: Prototype Stage) (Part 3 of 4)

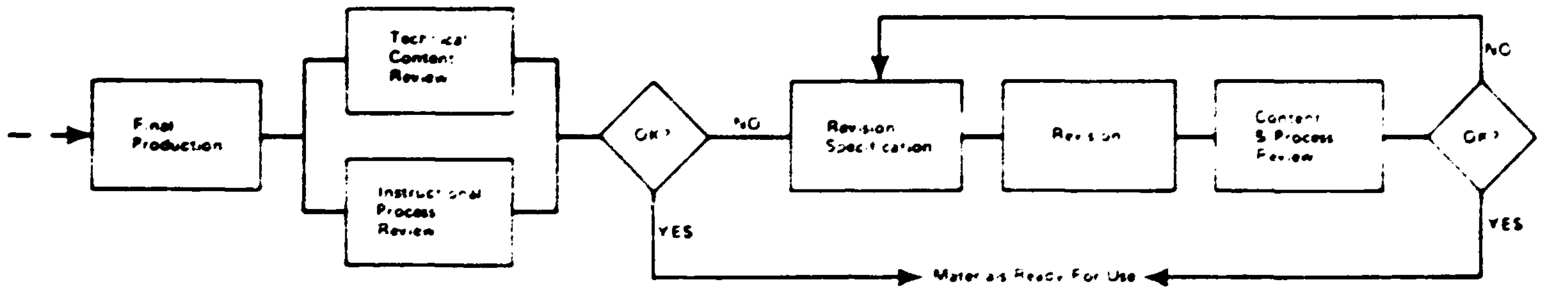

Figure 15. Development: Materials Tryout and Revision (Quality Control of Development: Final Production Stage) (Part 4 of 4)

throughout its life cycle, it will not only have to be managed properly, but it will need to be amenable to continuous evaluation and updating.

Once the instructional media and materials have entered the final production phase, the ISD team can turn its attention to developing a plan that will control implementation, operation, and long term evaluation of the training program. It is at this point that the basic instructional management system is established, as illustrated in figure 16. This system defines the roles of instructional personnel, the student management procedures, and the procedures for resource allocation and scheduling.

Built into the management process is a quality control system designed to continuously assess the effectiveness and palatability of the instructional materials, as well as the instructional management system itself. An illustration of this system is presented in figure 17. The objective of this quality control system is to provide a mechanism for identifying those pieces of instruction that require modification, and for assuring that the needed modifications will be made in a timely and smooth manner.

This is the final task of the ISD team. Upon its completion, the team will have developed, designed, and produced a superior instructional system, one which can be implemented and managed efficiently for the lifetime of the program. The built-in quality control system assures that the program will always accomplish what it was designed to do and that its materials will be revised to reflect the changes in conditions and constraints that will probably lie in the future. Such a program should be as fresh and effective at the end of its tenure as it was at the beginning.

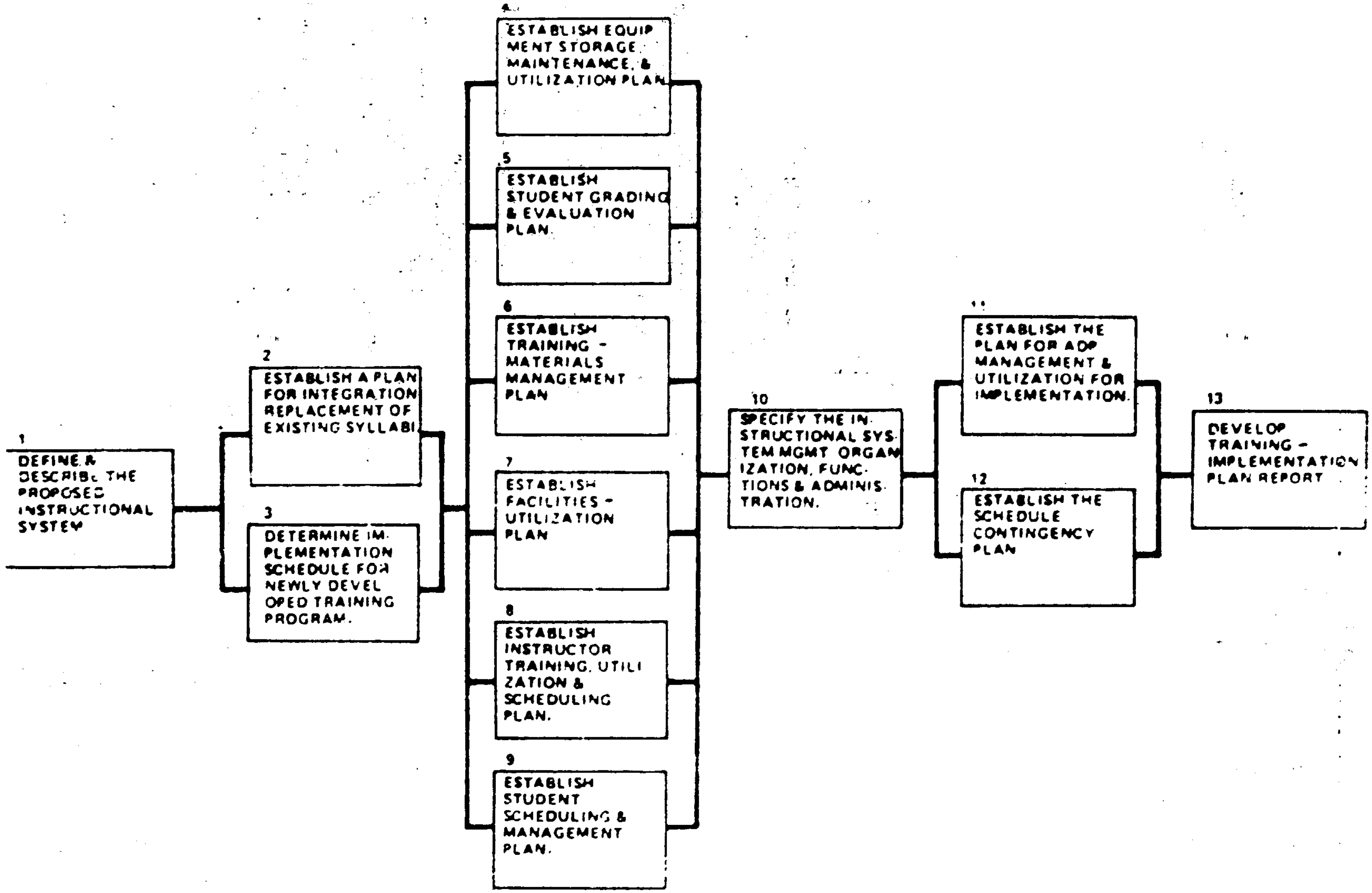

Figure [illegible] Design: Implementation Planning (The Implementation Planning Process)

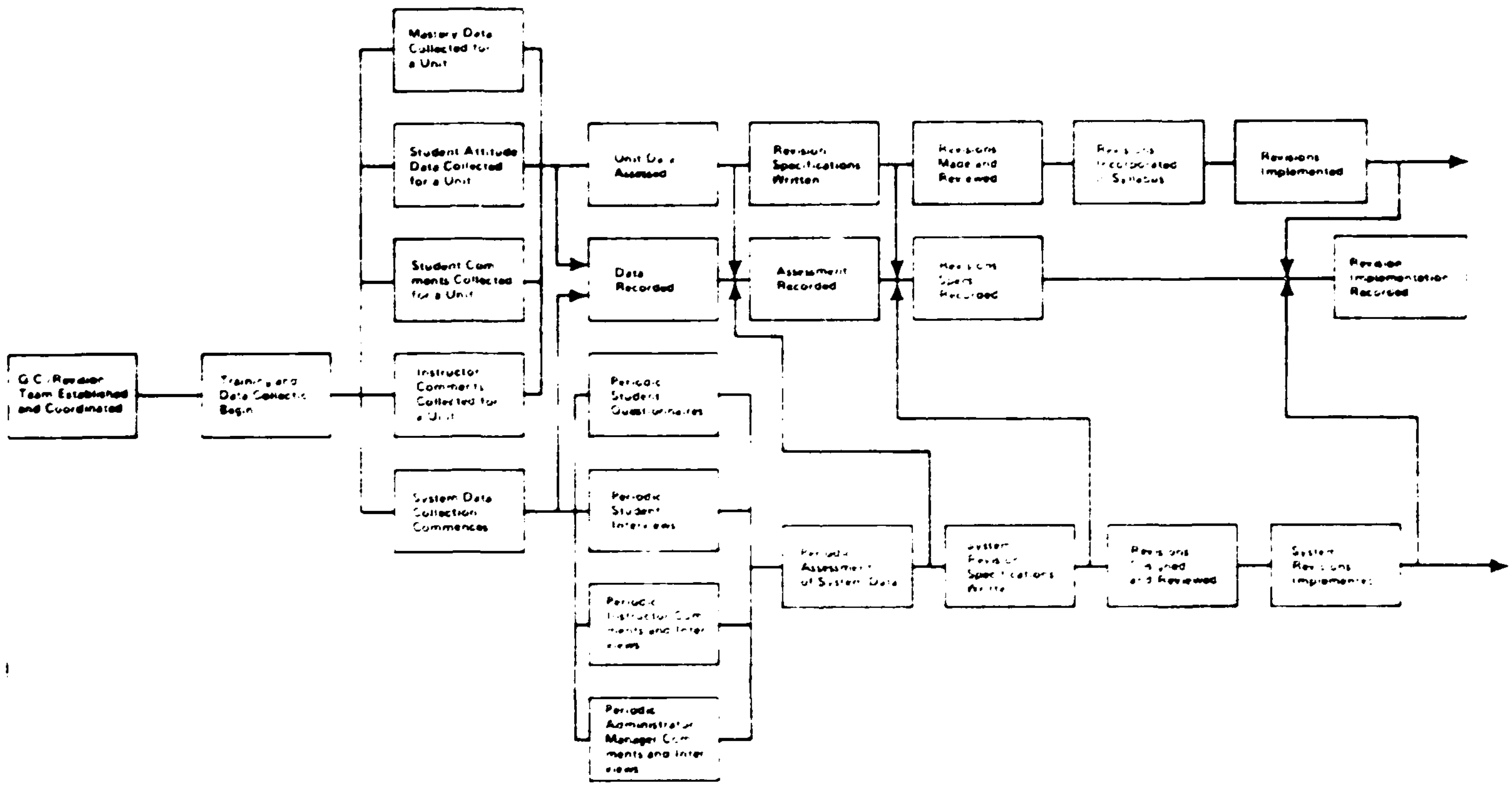

Figure 17. Quality Control: QC Data Collection and Evaluation and Revision (The Process for Conducting Internal and External Quality Control)

REFERENCES

Courseware, Inc. (June, 1977) "Fleet Aviation Instructional Systems Develop-ment Model," Courseware Technical Report, Vols. I-VII.

Montemerlo, M. D. and Tennyson, M. E. (February, 1976) "Instructional Sys Development: Conceptual Analysis and Comprehensive Bibliography," NAVTRAEQUIPCEN Report No. IH-257.

ISD Group NAVTRAEQUIPCEN (October, 1977) "Training Requirements for Aviation Weapon Systems," NAVTRAEQUIPCEN Specification MIL-T-29053 draft.

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